

# **2012 North Creek Sub-basin Water Quality Monitoring and Contaminant Source Survey Report**



**Provided to the City of Bothell, WA. - Under ILA #9710070097**

**Snohomish County Public Works Surface Water Management  
3000 Rockefeller Ave. M/S 607  
Everett, WA. 98201**



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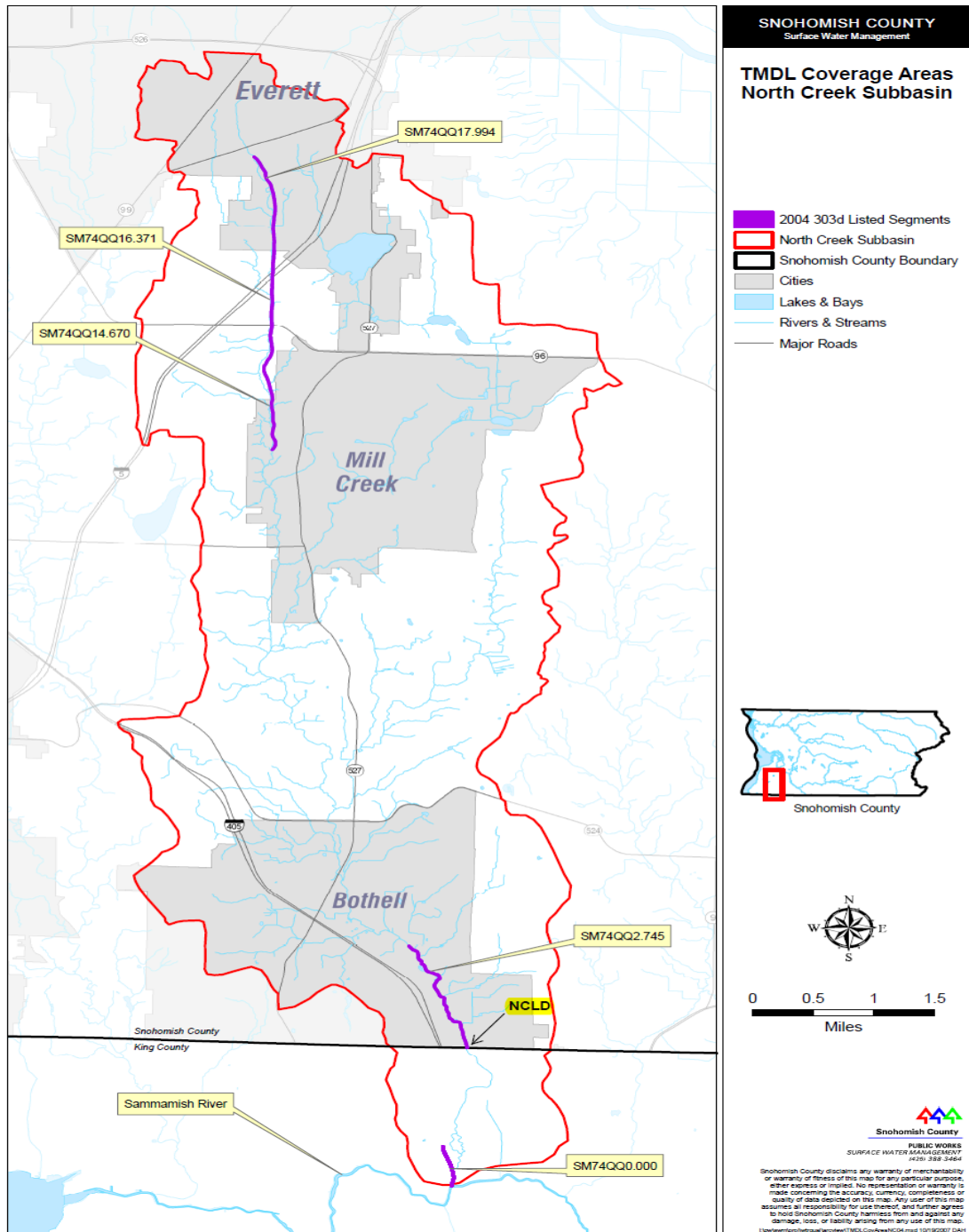
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## **Introduction and Study Area**

The City of Bothell (City) and Snohomish County (County) have a long standing inter-local agreement (ILA #9710070097), which allows Snohomish County to provide water quality services to the City. Water quality services are agreed upon annually. In 2012, services included routine water quality monitoring to determine compliance with State water quality standards and a contaminant source survey focused on identification of fecal coliform bacteria sources for those segments and tributaries of North Creek within the City of Bothell's jurisdiction (Figure 1).

The following report satisfies the County's obligation to the City for water quality services in 2012.

**Figure 1. North Creek Sub-basin and Sampling Location**



## Background

The County has carried out surface water quality monitoring on North Creek at the County line (NCLD) since 1992 (Figure 1). Monitoring data are compared to surface water quality standards to determine suitability for aquatic life and risk to human health. .

The Washington State Department of Ecology (Ecology) is responsible for establishing and implementing surface water quality standards. Washington State Administrative Code (WAC 173-201A) contains these standards.

North Creek at NCLD is classified in the Washington State Water Quality Standards (WAC 173-201A) as extraordinary contact recreation. The classification requires that:

- Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100ml, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colony forming units (cfu) / 100ml.

Those standards applicable to North Creek and parameters monitored for the City are found in table 1.

**Table 1. Washington State Water Quality Standards for Measurements at NCLD**

| Waterbody   | Fecal Coliform Bacteria Standards<br>Colonies/100ml |                       | Dissolved Oxygen mg/l<br>Lowest 1 day minimum<br>Core Summer Habitat | Temperature Deg C<br>Highest 7-DADMax<br>Core Summer Habitat | pH        | Turbidity<br>Nephelometric Turbidity Units (NTU)                                                       |
|-------------|-----------------------------------------------------|-----------------------|----------------------------------------------------------------------|--------------------------------------------------------------|-----------|--------------------------------------------------------------------------------------------------------|
|             | Standard                                            | Extraordinary Contact |                                                                      |                                                              |           |                                                                                                        |
| North Creek | Geometric Mean                                      | 50                    | 9.5                                                                  | 16                                                           | 6.5 – 8.5 | Shall not exceed 5 NTU over background when $\leq 50$ or a 10 percent increase when background is > 50 |
|             | 10 Percent not to Exceed                            | 100                   |                                                                      |                                                              |           |                                                                                                        |

Thornburgh (1996) showed that between 1992 and 1995, 29 percent of County fecal coliform sample results at NCLD exceeded the extraordinary primary contact standard for North Creek . Standards require that not more than 10 percent of samples shall exceed the criteria of 100 colonies / 100ml of sample.

Ecology is required by section 303d of the Clean Water Act to assess the status of waters and develop clean up plans for those determined to be impaired beyond standards. Ecology acted upon the exceedences of the fecal coliform standard for North Creek at NCLD, and in 1998, listed the segment upstream of NCLD as impaired (Figure 1).

As further required by the Clean Water Act, Ecology developed a clean-up plan, otherwise referred to as a Total Maximum Daily Load (TMDL). for North Creek. The TMDL was supported by a water quality technical study using long-term monitoring data collected by Snohomish County at NCLD from May 1992 – May 1998.

The technical study authored by Glenn (2001), is titled North Creek Fecal Coliform Total Maximum Daily Load Submittal Report Publication 02-10-020, [www.ecy.wa.gov/biblio/0103020.html](http://www.ecy.wa.gov/biblio/0103020.html). The TMDL's objective is to recommend to responsible stakeholders, such as the County and City, actions to assess and reduce discharges of fecal coliform bacteria to stormwater and/or receiving waters. These actions include, but are not limited to, water quality monitoring for trends analysis and source identification.

Ecology's assessments of the status of waters in 1998 and 2008, resulted in continuing the listing of impairment for the segment of North Creek upstream of NCLD (Figure 1).

In 2007, Ecology issued the National Pollution Discharge Elimination Systems (NPDES) Phase II Municipal Stormwater Permit to all small municipalities in Washington State, including Bothell. Appendix two of the permit required that Bothell develop a bacteria pollution control plan (BPCP) to address waterbodies, including North Creek, listed as impaired for fecal coliform bacteria. Bothell's BPCP is found at <http://www.ci.bothell.wa.us/Site/Content/Public%20Works/Surface%20Water%20Mgmt/FinalBPCPwithAppendix2011small.pdf>

The City's BPCP outlines a phased approach to achieve reductions in fecal coliform contamination observed in waterbodies. Phase three of the plan includes long term water quality monitoring of North Creek and targeted tributaries to describe trends and patterns of fecal coliform bacteria, assess potential exceedences of water quality standards, and utilize data to direct future source tracking surveys. The County's QAPP and the ILA supports the City's BPCP objectives and addresses requirements found in Appendix two of Bothell's draft 2013 – 2018 NPDES permit.

## Water Quality Monitoring

Consistent with the Snohomish County Fecal Coliform TMDL Quality Assurance Project Plan (QAPP) (Britsch 2009), ILA and Cities BPCP, the County continued monthly water quality monitoring at NCLD through 2012. Sampling was carried out for parameters using field and lab analytical methods identified in table 2.

**Table 2. 2012 Parameters Monitored at NCLD**

| Parameter              | Instrument    | Analytical Method |
|------------------------|---------------|-------------------|
| Fecal Coliform         | NA            | SM9222D           |
| Total Suspended Solids | NA            | SM2540B           |
| Temperature            | Hach Hydrolab | SM2550B-F         |
| Dissolved Oxygen       | Hach Hydrolab | SM4500OG          |
| pH                     | Hach Hydrolab | EPA150.1M         |
| Spec. Conductivity     | Hach Hydrolab | EPA120.1M         |
| Turbidity              | Hach 2100P #1 | EPA180.1          |

## Data Analysis Methods

Ecology uses Water Quality Program Policy (WQP) 1-11 to describe methods of data analysis used for placing a waterbody on the 303d list as impaired, and generally describes the process for de-listing.

The WQP, updated July 2012, requires that analysis of geometric means and 10 percent not to exceed standards for fecal coliform bacteria data be upon seasons as established in TMDLs. A minimum of 10 samples must be obtained and analyzed by water year (WY), having five each from the wet and dry seasons. Determination of month ranges used for seasonal analysis in this report is driven by (Glen 2001), where Ecology assigned June 1 –October 30 the dry season and November 1 – May 30 to the wet season.

Given the July 2012 WQP update, the 2012 WY dry season months for fecal coliform bacteria analysis include October 2011 and June – September 2012, whereas the wet season months include November – December 2011 and January – May 2012. All other parameters in this report are analyzed by calendar year, as the WQP does not require their analysis by WY.

It is of note that Ecology's approach to analysis of fecal coliform data using the 10 percent not to exceed standard is referred to the "raw scores" approach, whereby a stream segment is listed as impaired when greater than 10 percent of the measurements exceed the numeric criteria. Ecology (2002) recognized that use of the "raw scores" method for analysis of the 10 percent not to exceed standards results in an increased chance of type one and type two errors, where waterbodies are either listed as polluted when they should not be or not listed when they should be.

Snohomish County supports the State of Florida's approach for analysis of fecal coliform bacteria, whereby a minimum of the most recent 30 samples are analyzed using a binomial probability distribution at a 90 percent confidence interval to infer the true probability of impairment. This additional level of analysis is provided in the report.

## **Results and Discussion**

### **Fecal Coliform Bacteria**

Sufficient samples were gathered at NCLD during the 2012 WY to determine analyzed data as required by WAC 173-201A and the WQP. Fecal coliform bacteria results for the 2012 WY are found in table 3.

**Table 3. 2012 Fecal Coliform Bacteria Results – NCLD**

| Sample Date                 | Sample Time | Weather     | Water Color | Parameter                                     | Sample Result (cfu/100ml) | Qualifier |
|-----------------------------|-------------|-------------|-------------|-----------------------------------------------|---------------------------|-----------|
| <b>2011-2012 Wet Season</b> |             |             |             |                                               |                           |           |
| 11/2/2011                   | 12:55       | Dry         | Tannic      | Fecal Coliform                                | 26*                       | J         |
| 12/6/2011                   | 13:15       | Dry         | Tannic      | Fecal Coliform                                | 14                        |           |
| 2/1/2012                    | 12:55       | Rain        | Muddy       | Fecal Coliform                                | 380                       |           |
| 3/6/2012                    | 13:10       | Dry         | Tannic      | Fecal Coliform                                | 74                        |           |
| 4/2/2012                    | 13:20       | Dry         | Tannic      | Fecal Coliform                                | 8                         |           |
| 5/2/2012                    | 13:15       | Recent Rain | Tannic      | Fecal Coliform                                | 96                        |           |
|                             |             |             |             | <i>Seasonal Geomean</i>                       | 45                        |           |
|                             |             |             |             | <i>% Samples Exceeding 100 Colonies/100ml</i> | 14                        |           |
| <b>2012 Dry Season</b>      |             |             |             |                                               |                           |           |
| 6/1/2012                    | 12:45       | Rain        | Muddy       | Fecal Coliform                                | 1800                      |           |
| 7/11/2012                   | 12:49       | Rain        | Tannic      | Fecal Coliform                                | 120                       |           |
| 8/14/2012                   | 10:05       | Dry         | Tannic      | Fecal Coliform                                | 54                        |           |
| 9/5/2012                    | 13:10       | Dry         | Tannic      | Fecal Coliform                                | 44                        |           |
| 10/3/2012                   | 13:35       | Dry         | Tannic      | Fecal Coliform                                | 66                        |           |
|                             |             |             |             | <i>Seasonal Geomean</i>                       | 128                       |           |
|                             |             |             |             | <i>% Samples Exceeding 100 Colonies/100ml</i> | 40                        |           |
| <b>2012 Combined Season</b> |             |             |             |                                               |                           |           |
|                             |             |             |             | <i>Combined Season Geomean</i>                | 72                        | J         |
|                             |             |             |             | <i>% Samples Exceeding 100 Colonies/100ml</i> | 27                        | J         |

\*Note: Lab duplicate relative percent differences were exceeded for the November sample event. Sample is an estimate

### Wet Season Results and City of Everett Sewage Discharge

NCLD was in compliance with fecal coliform bacteria geometric mean standard during the 2012 WY wet season, but failed to meet 10 percent not to exceed standard.

On April 12, 2012, a City of Everett sewer line failed, causing a discharge of approximately one million gallons of raw sewage into North Creek, eight miles upstream of NCLD. Snohomish County collected seven sets of water quality samples at NCLD over three weeks following the discharge. Verified results of the County sewage spill sampling effort at NCLD are in table 4. Samples obtained from April 18 - 20th produced spikes in fecal coliform bacteria, ammonia and potassium, at levels commonly associated with sewage. Pollutant levels fell between April 20<sup>th</sup> and 24<sup>th</sup>. A rain event, sampled on April 25, is thought to have re-suspended pollutants, resulting in additional pollutant spikes. The County effort to monitor the sewage discharge was discontinued after April 25. Given the nature and severity of the sewage line discharge, results for fecal coliform bacteria gathered in response were excluded from WY 2012 or seasonal analysis to reduce bias.

While May sample results did not exhibit fecal coliform results consistent with sewage, June sample results were elevated.

### Dry Season Results

Dry season exceedences of the geometric mean and 10 percent not to exceed standard for fecal coliform bacteria standards were found at NCLD in 2012. Rain events likely contributed to exceedences of standards for at least two sample events during the 2012 dry season. The June sample event occurred during a storm, resulting in 1800 cfu/100ml. This is the second highest single sample result over the last five years at this location. Although not uncommon to find fecal coliform bacteria at these levels in stormwater, receiving waters generally do not exhibit results this high. It is possible that the June rain event re-suspended residual pollutants from the City of Everett sewage line discharge.

### Combined Season Results

The combined season geometric mean of 72 cfu/100ml exceeded the geometric mean standard. Twenty seven percent of samples exceeded 100 colonies, causing this station to fail both parts of the standard for WY 2012.

**Table 4. City of Everett Sewage Spill – Snohomish County Sampling Results at NCLD**

| Sample Date | NCLD (County Line) |                          |               |              |                |                         |                      |                       |                  |
|-------------|--------------------|--------------------------|---------------|--------------|----------------|-------------------------|----------------------|-----------------------|------------------|
|             | Weather            | Fecal Coliform cfu/100ml | Fluoride mg/l | Ammonia mg/l | Potassium mg/l | Ammonia/Potassium Ratio | Nitrate/Nitrite mg/l | Total Phosphorus mg/l | Surfactants mg/l |
| 4/16/2012   | Dry                | 45                       | ND            | ND           | 1.6            | 0.000                   | 0.48                 | 0.088                 | ND               |
| 4/18/2012   | Dry                | 140                      | ND            | 1.680        | 1.5            | 1.120                   | 0.46                 | 0.117                 | 0.048            |
| 4/19/2012   | Dry                | 20                       | ND            | 1.680        | 1.7            | 0.980                   | 0.48                 | 0.047                 | ND               |
| 4/20/2012   | Rain               | 820                      | ND            | 1.120        | 1.6            | 0.700                   | 0.34                 | 0.108                 | ND               |
| 4/23/2012   | Dry                | 15                       | ND            | ND           | 1.7            | 0.000                   | 0.44                 | 0.110                 | 0.036            |
| 4/24/2012   | Rain               | 14                       | ND            | ND           | 1.6            | 0.000                   | 0.47                 | 0.149                 | 0.032            |
| 4/25/2012   | Rain               | 190                      | ND            | ND           | 1.8            | 0.000                   | 0.52                 | 0.116                 | 0.031            |

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## Ranking and Probability of Impairment

Snohomish County's Microbial Water Quality Assessment (MWQA) program analyzes a 30 sample dataset, using a binomial probability distribution, to statistically assess the probability of true impairment.

A binomial probability distribution run on the most recent 30 samples (June 2010 – December 2012), using a 90 percent confidence interval, showed a 99.9 percent probability that > 10 percent of the combined season samples at NCLD truly exceed the criteria. This analysis provides statistically valid evidence of true impairment for the dataset under examination.

The same 30 sample dataset is also analyzed to determine the percent of samples exceeding 100 or 200 colonies / 100ml, depending upon the waterbody standard. The assigned rank dictates priority for contaminant source surveys.

Over the last 30 sample dataset at NCLD, 37 percent of combined season samples exceeded the extraordinary primary contract standard of 100 colonies / 100ml (Appendix A). When greater than 30 percent, but less than 50 percent of combined season samples exceed 100 colonies, Snohomish County assigns a site a MWQA rank of C, triggering prioritization for a contaminant source survey. A contaminant source survey is a phased approach utilizing GIS and field surveys upstream of the sample location to identify potential discharges to the receiving waters.

## Total Suspended Solids

Measures of total suspended solids (TSS) are often associated with increased levels of water pollution. Table 4 summarizes TSS measurements at NCLD in 2012. Jolley et.al (2001) found strong correlation between TSS in receiving waters and fecal coliform bacteria concentrations, concluding that bottom sediments re-suspended by storm flow influence fecal coliform concentrations found in surface waters. A preliminary correlative analysis using 2010 data (n=9), for one location on Little Bear Creek found a high degree of correlation between fecal coliform bacteria and TSS ( $r^2 = .87$ ) (Britsch 2011). These data suggest that re-suspension of bottom sediments, polluted by external sources may also be a driver for exceedences of fecal coliform standards at NCLD.

**Table 4. 2011 Total Suspended Solids at NCLD**

| Sample Date                   | Sample Time | Weather     | Water Color               | Sample Result (mg/l) | Qualifiers | Comment |
|-------------------------------|-------------|-------------|---------------------------|----------------------|------------|---------|
| 2/2/2012                      | 12:55       | Rain        | Muddy                     | 43                   | None       |         |
| 3/6/2012                      | 13:10       | Dry         | Tannic                    | 4                    | None       |         |
| 4/2/2011                      | 13:20       | Dry         | Tannic                    | 4                    | None       |         |
| 5/2/2012                      | 13:15       | Recent Rain | Tannic                    | 9                    | None       |         |
| 6/13/2012                     | 12:45       | Rain        | Muddy                     | 25                   | None       |         |
| 7/11/2012                     | 12:55       | Dry         | Tannic                    | 3                    | None       |         |
| 8/14/2012                     | 10:05       | Dry         | Tannic                    | 3                    | J          |         |
| 9/5/2012                      | 13:10       | Dry         | Tannic                    | 2                    | None       |         |
| 10/3/2012                     | 13:25       | Dry         | Tannic                    | 2                    | None       |         |
| 11/5/2012                     | 13:25       | Recent Rain | Tannic                    | 5                    | None       |         |
| 12/6/2012                     | 13:05       | Recent Rain | Muddy                     | 8                    | None       |         |
|                               |             |             |                           |                      |            |         |
| <b>Descriptive Statistics</b> |             |             | <b>Mean</b>               | 9.82                 | J          |         |
|                               |             |             | <b>Median</b>             | 4                    |            |         |
|                               |             |             | <b>Minimum</b>            | 2                    |            |         |
|                               |             |             | <b>Maximum</b>            | 43                   |            |         |
|                               |             |             | <b>Standard Deviation</b> | 12.81                |            |         |

Note: August lab duplicate result exceeded allowed relative percent difference. Sample result is an estimate.

## Temperature

North Creek is designated as core summer salmonid habitat, requiring that the seven day average of the daily maximum (7Dadmax) stream temperature not exceed 16°C at a probability frequency of more than once every ten years on average. Where a seven day average of the daily maximum cannot be determined, the WQP allows use of single grab samples to determine whether numeric temperature criteria have been exceeded. Ecology may list a waterbody as a category 5 (impaired and requiring a TMDL) using single grab data when, (1) a minimum of three exceedences exist from all data considered, and (2) at least ten percent of single grab values in a given year exceed the criteria.

Ecology's 2008 assessment resulted in listing this segment of North Creek (listing ID 7454 [http://apps.ecy.wa.gov/wats/ViewListing.aspx?LISTING\\_ID=7454](http://apps.ecy.wa.gov/wats/ViewListing.aspx?LISTING_ID=7454)) as category 2 (waters of concern) for temperature. Ecology determined that unpublished Snohomish County single grab sample data from 1998 was not sufficient for a category 5 listing of impairment. Snohomish County submitted 2011 grab sample data to Ecology, showing three consecutive exceedences of the standard during the summer critical period (25 percent of grab samples). This suggests that Ecology may list this segment as impaired during the 2012 fresh water assessment.

In 2012, stream grab samples temperatures at NCLD exceeded the core summer salmonid habitat criteria of 16°C during the July 11 single grab sample event (table 6). This one exceedence, if evaluated alone, would not justify determination of impairment according to the WQP. However, should Ecology evaluate 2011 grab sample data, they may determine this segment is impaired.

Additionally, Snohomish County gathered high quality continuous temperature data at NCLD on 30 minute intervals in 2007 and 2008. The 2008 results produced a 7Dadmax of 18.80°C. The 7DadMax was exceeded for 44 percent of the 2008 monitoring period. While this data has not been submitted to Ecology for assessment, it demonstrates exceedences of the standard in accordance with WAC 173-201A and the WQP.

Continuous temperature monitoring did not occur during 2012, at NCLD or any other location within the City.

## Dissolved Oxygen

North Creek is not allowed to fall below a minimum one day dissolved oxygen value of 9.5 mg/l at an average frequency greater than once in ten years.

The WQP allows use of single event grab sample data collected infrequently for assessment of impairment. A waterbody will be placed in category 5 (impaired and requiring a TMDL) when (1) a minimum of three exceedences exist from all data considered, and (2) at least ten percent of single grab sample values in a given year do not meet the criteria.

Ecology's 2008 freshwater assessment resulted in listing this segment (listing ID 7457 [http://apps.ecy.wa.gov/wats/ViewListing.aspx?LISTING\\_ID=7457](http://apps.ecy.wa.gov/wats/ViewListing.aspx?LISTING_ID=7457)) as category 5 (impaired) for dissolved oxygen. Ecology made this determination based upon data gathered by the City, Snohomish and King County's.

Where flow data exists, the WQP states that impairment may be determined using the 7 day consecutive low flow with a 10 year frequency (7Q10). That is, where values below the dissolved oxygen standard are found when flow is above the 7Q10, Ecology would list the segment as impaired, unless a significant amount of data exists during the summer critical period that is in compliance with the standard.

The County operated a flow gage at NCLD from May 1998 - May 2011, but calculation of the 7Q10 and comparison to dissolved oxygen values over the most recent 10 year period are outside the scope of this annual monitoring report.

The WQP does not allow single event grab sample data to make a determination of non-impairment, rather requires continuous dissolved oxygen data gathered at a minimum of 1 hour intervals during the critical period, generally June-September. A waterbody will be placed in TMDL category 1 (non-impaired) when data from the two most recent years, in which data exist, show no values below the standard.

As shown in table 6, dissolved oxygen values did not fall below 9.5 mg/l at NCLD in 2012. Over a ten year period (2003 – 2012), Snohomish County measured dissolved oxygen below 9.5 mg/l on eleven occasions, with nine during the critical summer period when flows would likely be at their lowest (Table 5). Outside an assessment of 7Q10 against individual dissolved oxygen results, over a ten year period of record, there are greater than 3 exceedences and results for calendar years 2007 and 2008 have greater than 10 percent of samples exceeding the criterion. This suggests that Ecology may continue list ID7457 as impaired for dissolved oxygen.

**Table 5. NCLD Dissolved Oxygen Exceedences 2003 - 2012**

| Sample Date | Dissolved Oxygen mg/l | Season |
|-------------|-----------------------|--------|
| 5/1/2003    | 9.4                   | Wet    |
| 8/3/2004    | 8.97                  | Dry    |
| 9/8/2004    | 9.3                   | Dry    |
| 9/7/2005    | 8.59                  | Dry    |
| 10/10/2006  | 9.4                   | Wet    |
| 6/5/2007    | 8.38                  | Dry    |
| 7/5/2007    | 9.1                   | Dry    |
| 7/9/2008    | 9.42                  | Dry    |
| 9/8/2008    | 8.27                  | Dry    |
| 5/5/2009    | 8.06                  | Dry    |
| 8/10/2011   | 9.4                   | Dry    |

#### pH

Standards require that pH for North Creek not fall all outside the range of 6.5 and 8.5. The WQP accepts evaluation of single sample data from the most recent two years for which adequate data exist. Ecology's 2008 freshwater assessment resulted in listing this segment (listing ID 51272 [http://apps.ecy.wa.gov/wats/ViewListing.aspx?LISTING\\_ID=51272](http://apps.ecy.wa.gov/wats/ViewListing.aspx?LISTING_ID=51272)) as category 1, or meeting water quality standards. Single sample pH values at NCLD did not exceed standards during 2012 (table 6), nor did pH exceed standards in 2011. The data suggests that Ecology may continue to consider this segment as meeting standards for pH during the 2012 assessment.

#### Conductivity

Washington State does not have fresh water standards for conductivity. Measurements of conductivity or ionic strength can be used as a surrogate to identify levels of inorganic dissolved pollutants, including heavy metals. Generally speaking, waters in Snohomish County with lower levels of pollutants also exhibit annual average conductivities below 100 us/cm. The mean conductivity at NCLD in 2011 was 129.59 (table 6), much lower than the 2011 mean of 156.26 us/cm.

#### Turbidity

Average or mean turbidities for 2012 were measured at 6.36 Nephelometric Turbidity Units (NTU) (table 6). These values could be considered annual background for comparison to water quality standards. As such, the February and June sample results of 23.2 and 14.3 NTU could be considered in exceedence of standards. It should be noted that these measurements were gathered during rain events.

**Table 6. 2012 Insitu Results at NCLD**

| Sample Date                   | Sample Time | Weather     | Water Color | Instrument Hydrolab       | Temp. (Deg C) | Dissolved Oxygen (mg/l) | pH (units) | Cond. us/cm | Turbidity (NTU) | Qualifiers |
|-------------------------------|-------------|-------------|-------------|---------------------------|---------------|-------------------------|------------|-------------|-----------------|------------|
| 2/2/2012                      | 12:55       | Rain        | Muddy       | Skipper                   | 7.09          | 11.5                    | 7.32       | 87.5        | 23.2            | None       |
| 3/6/2012                      | 13:10       | Dry         | Tannic      | Skipper                   | 5.45          | 12.29                   | 7.54       | 115.2       | 3.54            | None       |
| 4/2/2011                      | 13:20       | Dry         | Tannic      | Skipper                   | 9.45          | 11.28                   | 7.51       | 109         | 2.98            | None       |
| 5/2/2012                      | 13:15       | Recent Rain | Tannic      | Skipper                   | 11.25         | 10.88                   | 7.82       | 113.9       | 5               | None       |
| 6/13/2012                     | 12:45       | Rain        | Muddy       | Skipper                   | 13.37         | 9.9                     | 7.53       | 123.1       | 14.3            | None       |
| 7/11/2012                     | 12:55       | Dry         | Tannic      | Lil' Buddy                | 17.21         | 9.99                    | 7.91       | 178.9       | 3.63            | None       |
| 8/14/2012                     | 10:05       | Dry         | Tannic      | Lil' Buddy                | 15.5          | 9.66                    | 7.75       | 148.8       | 3.64            | None       |
| 9/5/2012                      | 13:10       | Dry         | Tannic      | Skipper                   | 15.24         | 10.48                   | 8.06       | 172.7       | 2.39            | None       |
| 10/3/2012                     | 13:25       | Dry         | Tannic      | Skipper                   | 11.14         | 10.96                   | 7.9        | 173.7       | 3.2             | None       |
| 11/5/2012                     | 13:25       | Recent Rain | Tannic      | Skipper                   | 12.79         | 10.01                   | 7.51       | 118.6       | 2.63            | None       |
| 12/6/2012                     | 13:05       | Recent Rain | Muddy       | Skipper                   | 8.32          | 11.28                   | 7.25       | 84.1        | 5.43            | None       |
|                               |             |             |             |                           |               |                         |            |             |                 |            |
| <b>Descriptive Statistics</b> |             |             |             | <b>Mean</b>               | 11.53         | 10.75                   | 7.65       | 129.59      | 6.36            |            |
|                               |             |             |             | <b>Median</b>             | 11.25         | 10.88                   | 7.54       | 118.6       | 3.63            |            |
|                               |             |             |             | <b>Minimum</b>            | 5.45          | 9.66                    | 7.25       | 84.1        | 2.39            |            |
|                               |             |             |             | <b>Maximum</b>            | 17.21         | 12.29                   | 8.06       | 178.9       | 23.2            |            |
|                               |             |             |             | <b>Standard Deviation</b> | 3.72          | 0.82                    | 0.26       | 33.89       | 6.51            |            |

Note: Red text indicates a sample not meeting Washington State Water Quality Standards.

Snohomish County submits sample results to Ecology for storage in its' Environmental Information Management System (EIM). Data gathered at any Snohomish County water quality monitoring station 2010 to present, including NCLD may be obtained at <https://fortress.wa.gov/ecy/eimreporting/Detail.asp?Type=Study&ID=66789673&RecordsPerPage=100&RecordPage=1>

## **Data Quality Control**

The primary purpose of establishing data quality objectives and reviewing data is to ensure that environmental programs produce datasets of known quality for decision making.

Data verification is the process of evaluating the completeness, correctness, and conformance of a specific dataset against the method, procedural, or contractual requirement. Data verification evaluates how closely the QAPP and established procedures or methods were followed (EPA 2002). Field activities and documentation, sample receipt, preparation, analysis and laboratory reports are typical records and processes evaluated during data verification. Snohomish County's TMDL Monitoring QAPP follows EPA (2002) and Mathieu (2006) guidelines for data verification and validation.

### Field Sample and Measurement Quality Control

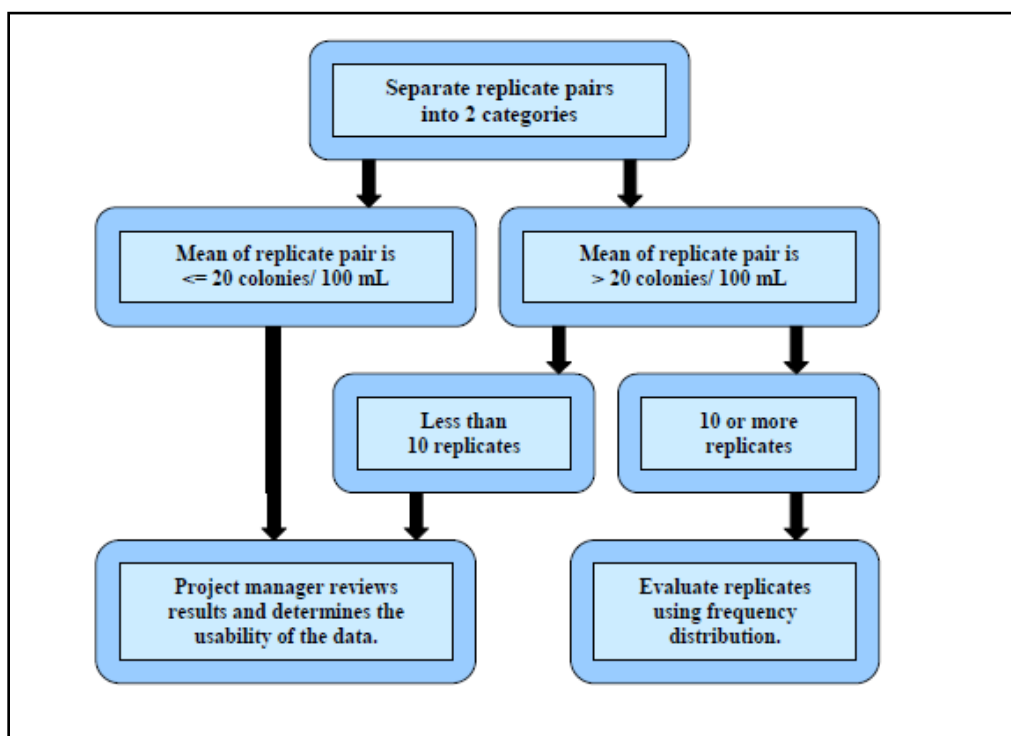
Samples were gathered and measurements taken at NCLD with 91 percent completeness and without rejection during the 2012 monitoring period. The completeness goal for samples and measurements is set at 70 percent. Calibration standards were within expiration date. Field instruments pre and post monitoring calibrations were 100 percent successful. One hundred percent of samples were kept at or below hold temperatures and analyzed within method specific hold times.

Samples and measurements were not gathered at NCLD in January 2012 as data was being analyzed to modify and identify County-wide sampling locations for 2012.

## Field Duplicates

On an annual basis, the County randomly assigns sites where field duplicate sampling will occur. For CY 2012, NCLD was not assigned field duplicate samples. The County's QAPP established fecal coliform field duplicate data quality objectives as recommended by Mathieu (2006), where 50 percent of annual fecal coliform duplicate pairs for where means are  $\leq 20$  colonies, must exhibit  $< 20$  percent relative standard deviation (RSD) and 90 percent of the of the same duplicate results must be  $< 50$  percent different. The process for evaluating fecal coliform field duplicate samples is illustrated in figure 2.

**Figure 2. Fecal Coliform Field Duplicate Evaluation Process (Mathieu 2006).**



Where fecal coliform mean duplicate results are  $\leq 20$  colonies, the ability to replicate results with precision as established in the QAPP has been poor. Eight and five individual sets of fecal coliform field duplicates where means  $\leq 20$  colonies were qualified as rejected in 2010 and 2011 respectively because the RSD's exceeded 50 percent. Variability in stream conditions, sampling methods, and analytical methods all affect precision.

Mathieu (2006) indicates that where the mean of duplicate pairs is  $\leq 20$  colonies, project managers review results for determination of data usability. No other clear recommendations are made by Mathieu (2006) on how to treat data where the RSD's for these data exceed criteria.

Sargeant (2000) wrote that where duplicate means are close to method detection limits, RSD's are expected to be greater than 50 percent, and data are accepted for use. The treatment of sample data or resulting analysis of geometric means are not impacted by findings that RSD's failed to pass criteria for means of duplicate pairs  $\leq 20$  colonies.

An evaluation of bacteria field duplicate pairs in 2010 and 2011 with means  $\leq 20$  colonies found the greatest RSD to be 113 percent where the original sample result was 2 colonies and the duplicate result was 18 colonies. In no case did any sample or field duplicate result, over the 48 pairs evaluated, fall outside of an observed range for each station. The average RSD's across all samples in 2010 and 2011 were 32 percent and 34 percent respectively.

Despite these difficulties, other measures of quality control such as field blanks, laboratory duplicate RPD's and lab method blanks were dominated by acceptable results.

It is recommended that future QAPP's set fecal coliform bacteria field duplicate RSD's for means  $\leq 20$  at higher levels to acknowledge variability in stream conditions, sampling and analytical methods.

### Field Measurements

Prior to the beginning of each sample collection run, Hach – Hydrolab™ instruments used for the collection of in-stream measurements were calibrated for dissolved oxygen, conductivity and pH in accordance with manufacturers recommendations. Temperature sensor calibrations were conducted annually by the manufacturer. Post monitoring calibration checks are conducted to ensure sensor stability and verify measurement accuracy. Instrument calibrations and checks are documented on hardcopy forms and kept with each instruments calibration records. On an annual basis each instrument receives factory calibration and maintenance including software or firmware updates. Hach 2100P™ handheld turbidimeters are used to measure in-stream turbidity. Turbidimeters receive in-house quarterly primary calibrations and secondary calibration checks prior to each sample run in accordance with manufactures recommendations. Electronic records of calibrations are used to document the occurrence of calibrations, verify instrument performance, and determine if completeness goals are met.

In July of 2012, during factory evaluation of Hydrolab™ instruments, it was discovered that the Skippers dissolved oxygen sensor had moisture under the lens, causing unacceptable fluctuations in dissolved oxygen during temperature swings ranging from Zero to 20° C. It was determined that the fluctuations in factory measurements did not impact the quality of prior field measurements given minimal field temperature fluctuations and successful pre and post

monitoring calibrations. July and August field measurements were taken using Lil Buddy, which has sensors and software identical to the Skipper unit. The Skippers' dissolved oxygen sensor was replaced and utilized the same methods for analysis. Despite having to utilize two different Hydrolab™ Multi-probe instruments, all field measurements are verified usable without qualification.

### Lab Quality Control

The County requests that lab duplicate analysis be performed on County samples where field duplicates are obtained. In the absence of this request, the contract lab runs lab quality control on other client samples.

Lab duplicate analysis for fecal coliform bacteria performed on other lab client samples on 7/12/2012 resulted in relative percent difference which exceeded lab control limits of 50 percent difference. July 2012 fecal coliform sample results were qualified as estimates (table 3).

Lab duplicate analysis for TSS performed on other lab client samples on 8/16/2012, resulted in a relative percent difference which exceeded lab control limits of 32 percent difference. August 2012 TSS results were qualified as estimates (table 4).

Rates of fecal coliform and TSS lab duplicate pairs meeting criteria suggest good analytical precision and adherence to method based standard operating procedures.

All lab method blanks for fecal coliform bacteria and total suspended solids were less than the method detection limits. Recoveries of standard reference materials for TSS were all within acceptable limits.

### **Findings and Recommendations**

Water quality standards at NCLD during the 2012 monitoring period were exceeded for fecal coliform bacteria, temperature and turbidity. While there were no documented excursions of the dissolved oxygen standard for 2012, interpretation of the WQP suggests that County flow and dissolved oxygen data could be evaluated further to assess impairment. While standards were exceeded for temperature and turbidity, the exceedences would likely not result in Ecology's determination of impairment over the 2012 monitoring period.

Exceedences of fecal coliform bacteria standards for WY 2012 were analyzed consistent with the WQP, indicating that Ecology would likely make the same determination.

The County analyzed the most current 30 fecal coliform sample dataset for assignment of a MWQA rank. The analysis shows that 37 percent of combined season samples exceed the second part of the fecal coliform standard, i.e., 100 colonies / 100ml. When  $> 30$  but  $\leq 50$  percent of fecal coliform samples exceed the second part of the criteria, i.e., 100 colonies / 100ml, the County recommends continued monitoring and prioritized phased contaminant source surveys.

Additionally, a binomial probability distribution, using a 90 percent confidence interval, was run on the most current 30 fecal coliform samples to assess the true probability of impairment. Results show a 99.9 percent probability that  $> 10$  percent of the combined season samples at NCLD exceed 100 cfu /100ml.

Based upon results, the County recommends continue water quality monitoring at NCLD, and focused contaminant source surveys to isolate potential sources of fecal coliform in 2013.

An evaluation of flow to calculate the 7Q10 as compared to dissolved oxygen results over the last 10 year period is recommended to evaluate dissolved oxygen for attainment of standards per the WQP. Relationships between dry season flow, rainfall, TSS and fecal coliform values could be explored to aid in determining if storm event driven re-suspension of bottom sediments contributes to exceedences of fecal coliform standards at NCLD.

## Contaminant Source Survey

### Introduction

Ecology issued the City a Phase II NPDES permit in 2007, which required development of a bacteria pollution control plan (BPCP) to address waterbodies listed as impaired for fecal coliform bacteria. The City's BPCP included long term monitoring of North Creek and targeted tributaries to assess exceedences of water quality standards and direct future source tracking surveys. The recently issued draft 2013-2018 Phase II NPDES permit carries the requirements to conduct monitoring and source tracking forward.

The City collected fecal coliform samples (2003 – 2007) on Crystal Creek 100ft upstream of the confluence with North Creek (Figure 3). An analysis found that 63 percent of samples (n=38) exceeded the 100 colony water quality standard for extraordinary primary recreational contact. Ongoing monitoring of water quality, habitat and biological metrics on Crystal/Queens Borough Creek has been conducted by the City. The Cities 2010 Stream Health report ranked the creek as severely impaired based upon an esoteric impairment score.

<http://www.ci.bothell.wa.us/Site/Content/Public%20Works/Surface%20Water%20Mgmt/fnlrptStreamHealth2010.pdf>

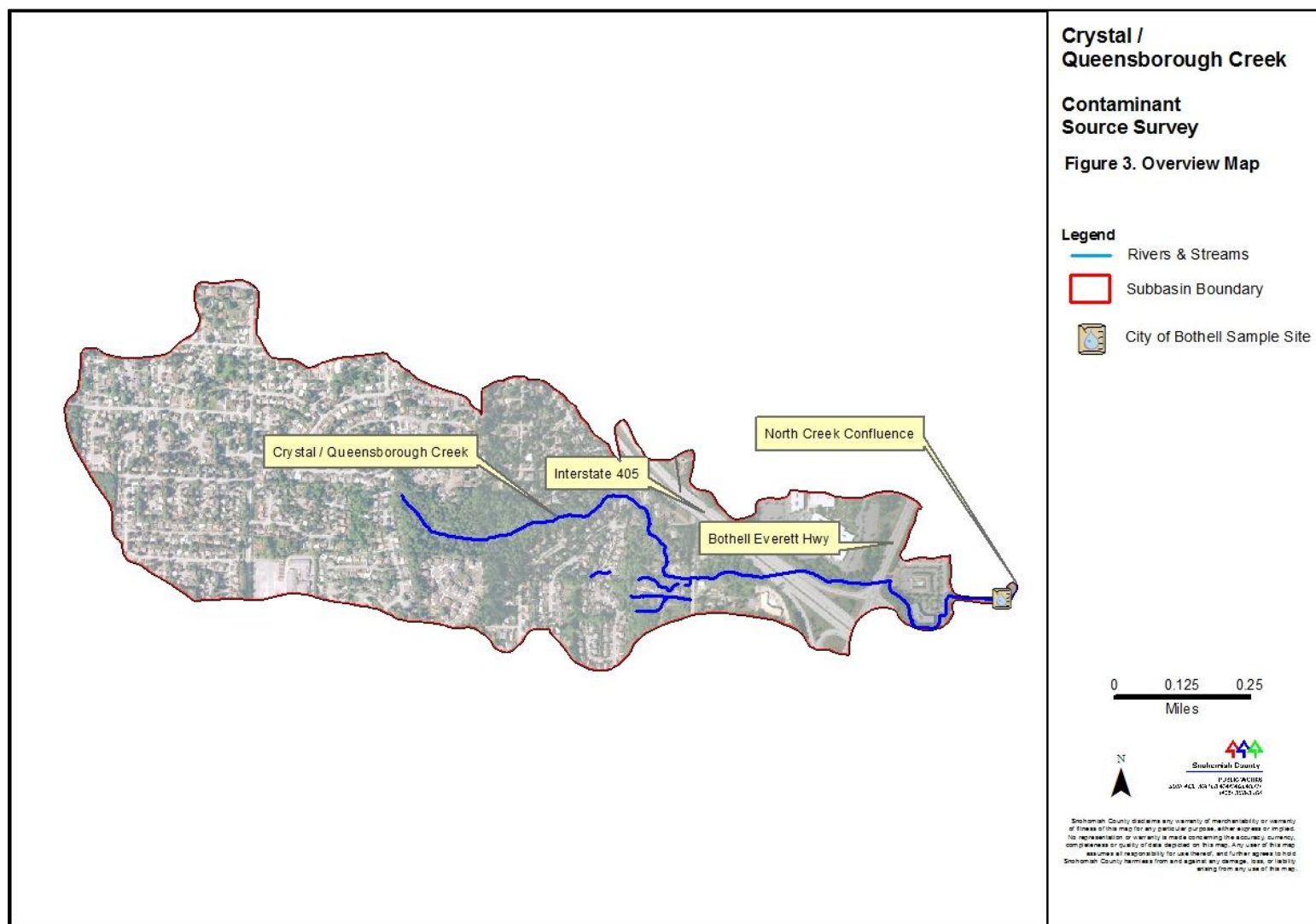
Based upon these assessments, the City requested the County conduct a Contaminant Source Survey (CSS) on Crystal/Queens Borough Creek to identify potential sources of fecal coliform bacteria.

### Study Area

Crystal/Queens Borough Creek is a tributary to North Creek. It is located completely within the City of Bothell's jurisdiction and, from its' confluence with North Creek to headwaters, is approximately 1.6 miles in length. The sub-basin is dominated by high density commercial and residential land use and crosses west to east under Interstate 405 and Bothell Everett Highway prior to its' confluence with North Creek. While the stream's upper reaches are forested within a deep ravine, its' highly impervious nature and density of storm sewer systems suggest potential for a degraded stream system (Figure 3). Based upon data collected in 2003, Ecology's 2008 assessment listed segment 45735 of Crystal/Queens Borough Creek as impaired for fecal coliform bacteria. [http://apps.ecy.wa.gov/wats08/ViewListing.aspx?LISTING\\_ID=45735](http://apps.ecy.wa.gov/wats08/ViewListing.aspx?LISTING_ID=45735)

Contaminant source survey methods call for splitting the study area into distinct stream segments. Crystal/Queensborough Creek was divided into three survey segments, as described later.

Figure 3. Crystal / Queensborough Creek Sub-basin



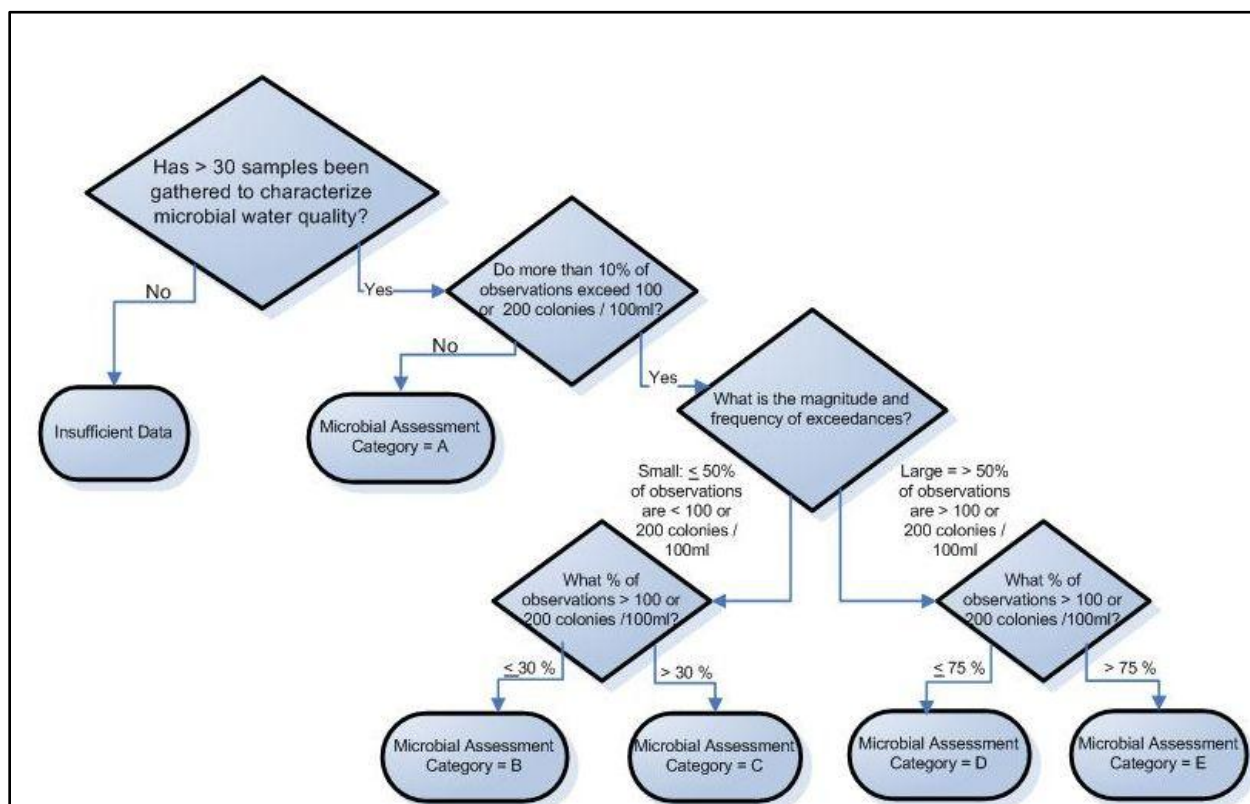
## CSS Background

As described in Britsch (2009), microbial water quality assessment (MWQA) ranks are established based upon the percentage of samples which exceed the waterbodies designated recreational contact 10 percent not to exceed standard (Figure 4). The rank that a sampling location receives dictates the level of CSS effort.

Ranking a sampling location based upon the percentage of samples which exceed the extraordinary recreation contact threshold is consistent with the extraordinary contact 10 percent not to exceed standard for North Creek where not more than 10 percent of samples used for calculation of a geometric mean shall exceed 100 colonies.

An analysis of fecal coliform data for Crystal/Queens Borough Creek found that 63 percent of samples 2003 – 2007 (n=38) exceeded 100 colonies/100ml, which using the decision tree in figure 4, assigns a MWQA rank of D to this station.

**Figure 4. Snohomish County MWQA Rank Decision Tree**



Adapted from PBS&J 2008 – Decision tree for assigning monitoring locations to microbial water quality assessment categories based upon observed fecal coliform concentrations. MWQA categories A through E are based upon the percentage of samples at a given site that exceed 100 or 200 CFU /100ml, using exceedance frequency break points of 10%, 30%, 50%, and 75%.

Given the MWQA rank of D, a three phased CSS approach as described in figure 5 is implemented.

**Figure 5. Contaminant Source Survey Description.**

- Phase 1 CSS : Basic Investigation: includes basic (screening level) analysis using available bacteria data to identify patterns and trends that may be present. These analyses are conducted in tandem with routine observations of potential bacteria sources during each monthly sampling visit. Notes are recorded on field data sheets.
- Phase 2 CSS: Intermediate Investigation: includes all elements of Phase 1, plus GIS analysis and initial source tracking to determine likely sources of bacteria. GIS layers include, but aren't limited to, roads, streams, water quality complaints, permitted dairy facilities, dry weather outfall screening data, farm windshield survey data, sewer/septic data, parcel ownership, land use, and commercial animal handling facility inspection data. The order of activities conducted under a Phase 2 CSS is as follows:
  - Basic data synthesis to determine trends and review of field notes
  - GIS analysis of upstream areas
  - Field contaminant source survey – windshield survey and stream walk
  - Source tracking using advanced parameters if potential source is identified
  - Review of GIS analysis, source tracking data and observations to re classify a MWQA category and/or identify potential source
  - If source is identified, work with stakeholders to remove source
- Phase 3 CSS: Advanced Investigation: includes all elements of Phase 1 and 2 plus notification to the health district and potential use of microbial source tracking techniques where sources are unclear or in need of confirmation.

### **CSS Phase One**

Phase one of CSS includes a basic analysis of bacteria data to identify patterns. From July 2003 through April 2007, the City collected 38 samples on Crystal/Queens Borough Creek for analysis of fecal coliform bacteria. Sampling efforts were concentrated by season with several sample events occurring within the same months. No samples were collected in 2005. State water quality standards for analysis of fecal coliform data indicate that when averaging bacteria for comparison to the geometric means criteria, it is preferable to average by season and include five or more collection events within each period. The period of averaging should not exceed twelve months, and should have sample collection dates well distributed throughout the reporting period. Further, the WQP requires that bacteria data be

analyzed by water year. Table 7 provides an analysis of Crystal/Queens Borough Creek fecal coliform data in accordance with State water quality standards and the WQP.

**Table 7. Crystal/Queens Borough Creek Seasonal Fecal Coliform Bacteria Results (2003-2007)**

| Geomeans by WY and Season | n = | Seasonal Geomean cfu / 100ml | % samples > 100 colonies / 100ml |
|---------------------------|-----|------------------------------|----------------------------------|
| 2003 Dry Season           | 11  | 240                          | 100                              |
| 2003 - 2004 Wet Season    | 7   | 150                          | 42                               |
| 2006 Dry Season           | 7   | 166                          | 85                               |
| 2007 Wet Season           | 10  | 54                           | 20                               |
| 2007 Dry Season*          | 3   | 159                          | 66                               |

Note: \*2007 dry season sample volume not sufficient for reliable geometric mean calculation

Although samples were evenly distributed within each season, the numbers of samples within each WY and season differ. While this impacts comparison of results by season and WY, with the exception of 2007, sample volumes are adequate for analysis. Seasonal analysis of geometric means and percent of samples exceeding 100 colonies shows that all seasons exceeded both parts of the extraordinary primary contact recreation water quality standard (Table 1). Exceedences are dominated by dry seasons. Snohomish County finds similar seasonal patterns of exceedences at other monitoring stations. Historical storm events during sampling at this location are not known. Depending upon the length of antecedent periods, dry season storm event sampling can produce spikes in fecal coliform bacteria due to build up or re-growth of bacteria either in the natural or build systems.

This analysis helped support and inform the decision to focus the CSS field survey on only the dry season. Other factors supporting the decision included, known sewer lines exposed to surface and available budget.

### CSS Phase Two

Geographical Information Systems (GIS) analysis of the study area was conducted to identify potential sources, determine land ownerships and drainage system patterns or points of discharge, segment survey reaches and plan field work (Figure 6).

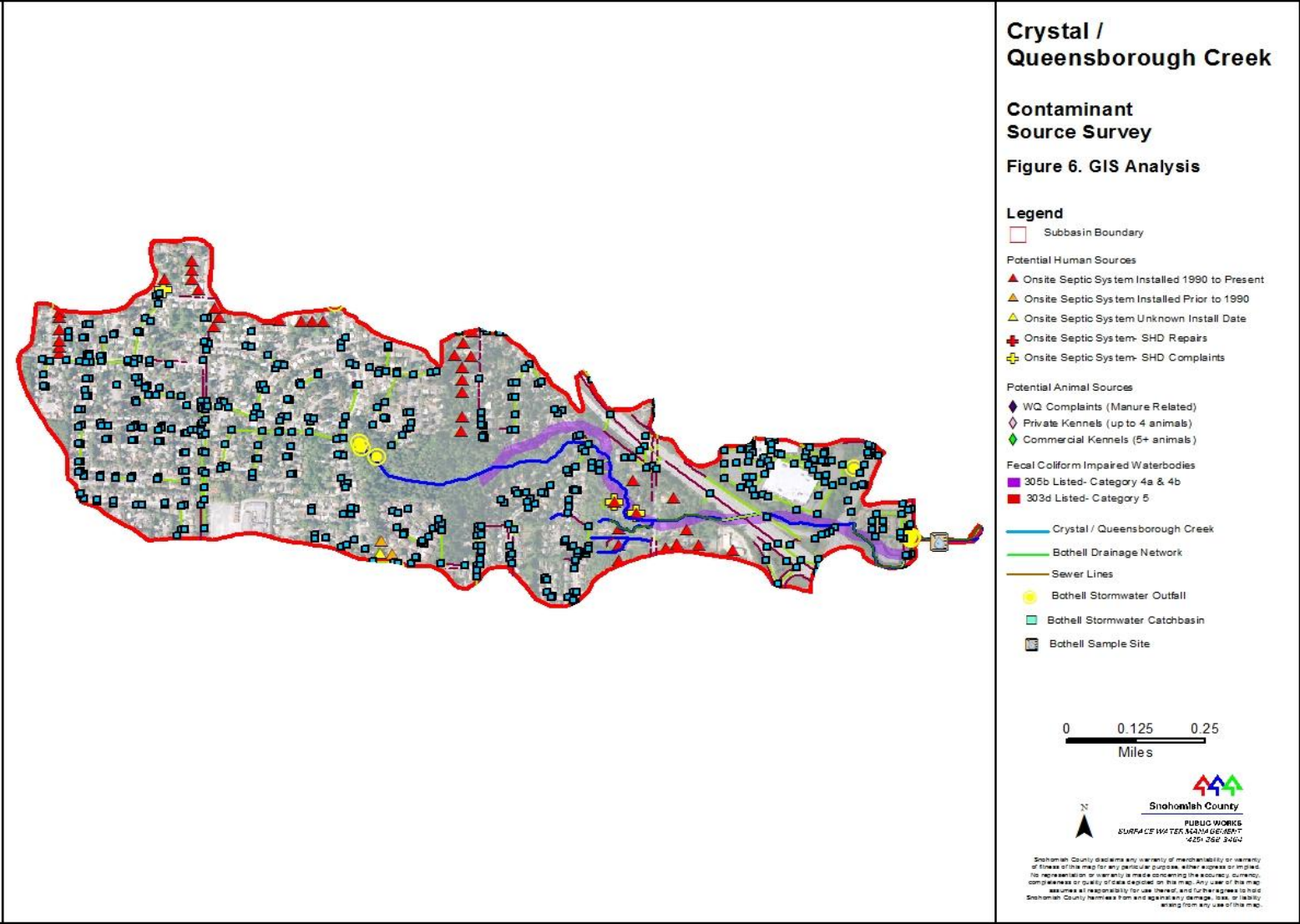
A preliminary GIS analysis identifies areas where potential sources for fecal coliform bacteria may be found. Human sources can originate from potentially failing septic system discharges and illicit connections within the City's 10.17 miles of piped storm sewers. The City expressed concern that locations where sewer lines cross under the creek cause potential for ex-filtration

during summer months. This was of particular concern in the upper reaches where the sewer line is exposed. Domestic pet waste found within parks or along walking trails and sidewalks can contribute pollutants. Sediment residing in storm drainage systems and receiving waters can harbor fecal coliform bacteria and be re-suspended during storm events. Waste from wildlife that may reside within drainage systems, wetlands and forested areas can also contribute to bacteria problems.

The GIS analysis revealed the following;

- The creek and it's watershed was 100 percent contained within the City
- The sub-basin is 387 square acres
- 497 known storm sewer catch basins are within the sub basin
- The sub basin contains 10.17 miles of piped storm sewer systems
- 1.6 miles of creek were included in the survey area
- Ecology's 2008 assessment listed the creek as a category 4a for fecal coliform bacteria (impaired with a TMDL)
- Forty six parcels were within 50ft of the creek
- Sewer lines cross under the creek in 4 locations – potential for ex-filtration
- Six known City outfalls discharge directly to the creek
- Two historic septic system complaints were identified with no apparent need for repair
- There are no known historic manure related water quality complaints
- There are no known and licensed private or commercial dog kennels
- Two Washington State Department of Transportation stormwater ponds discharge to the creek

Figure 6. Crystal / Queensborough Creek GIS Analysis



## Field Survey Results

Based upon the GIS analysis, CSS field survey segments were divided into three 0.5 mile reaches. Surveys involve the use of a Trimble™ GeoXT Geographical Positioning System (GPS) loaded with ortho photographs of the study area and a data dictionary customized for gathering fecal coliform source information. The data dictionary includes identification of potential human and animal (wild and domestic) sources, identification of direct and ongoing discharges, evaluation of stormwater conveyance systems and indicators related to the presence of pollutants such as odor. As field staff walk each segment of the stream corridor, points (locations) are gathered where a potential source or feature such as storm water or sewage infrastructure could present concerns. Photos and field notes are taken to document findings. The County's CSS field survey protocols are described further in (Britsch et.al. 2012).

Surveys were carried out from August 28 – 30, 2012. Staff began the survey at the confluence with North Creek and walked the corridor west to the creeks end (Figure 3). A total of seventeen points were gathered over the three segments surveyed. No active discharges of human or animal waste to the creek were identified.

Segment three contains the highest observed potential for human sources of fecal coliform bacteria. Points gathered are primarily related to either storm or sewage system infrastructure. Nine sewer standpipes located either within the wetted width or next to the creek are impacted by erosion. Sewer standpipe erosion has created the potential for ex-filtration, overflow or mixing with receiving waters during rain events. The presence of garbage and human activity next to the stream in the upper reaches of segment three indicates potential for human feces to contribute to bacteria loading. No farms having domestic animals or inadequate best management practices were identified. Further, the presence of waterfowl or wildlife such as beaver, coyote or deer was not observed.

Segment one of the creek was surveyed on August 28. The segment runs from the confluence with North Creek to I-405 (Figure 7). The segment is almost entirely channelized through the Canyon Park Business Center. The business center has many areas with maintained lawns on automated sprinkler systems, walking trails and planting beds in and around buildings, sidewalks and parking areas. The section of the creek that is located upstream of the Bothell-Everett Highway is a densely vegetated scrub shrub/forested wetland bounded by I-405, Bothell-Everett Highway, and the Phillips Ultrasound Business complex.

### Figure 7. CSS Segment One

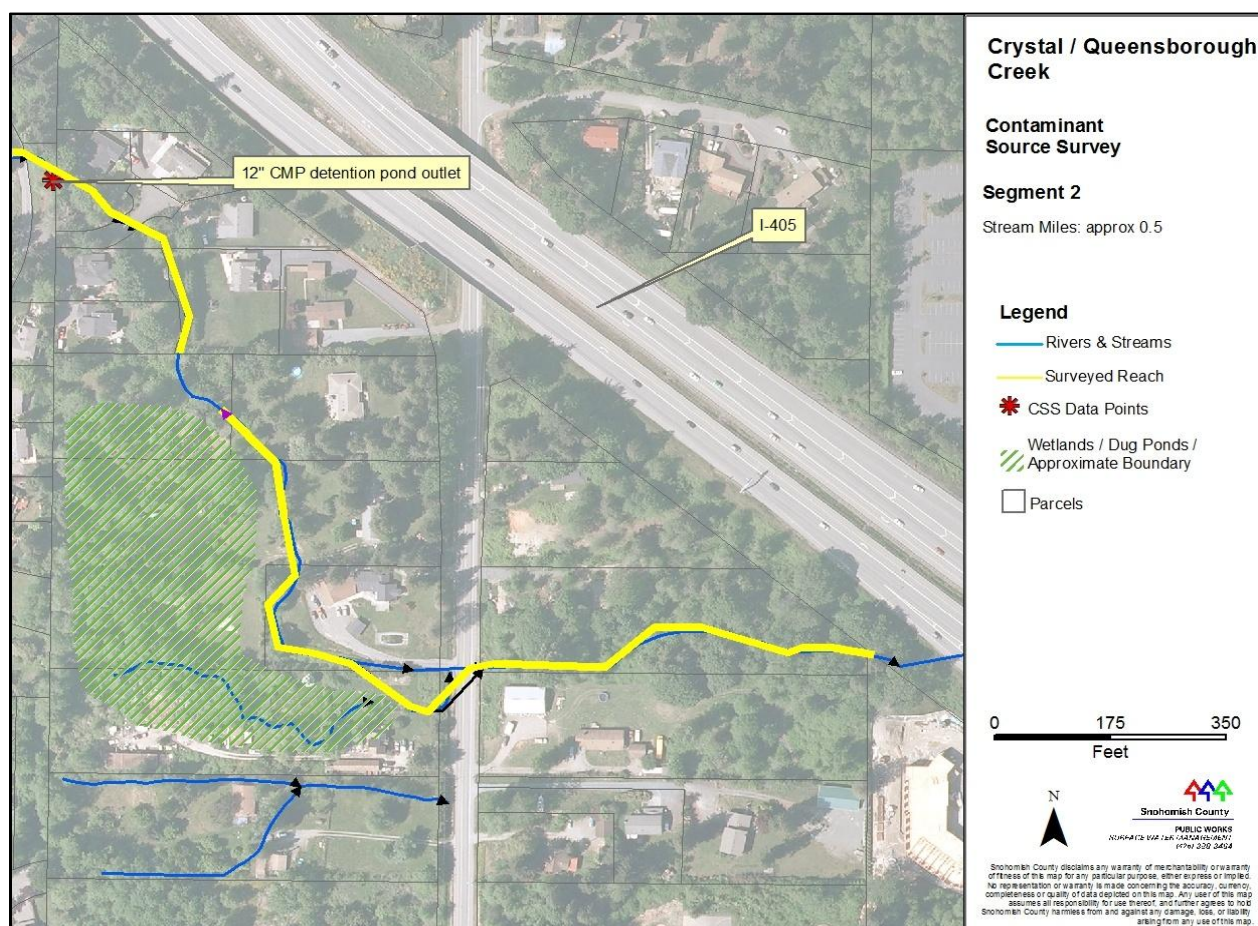


## Segment Two

Segment two of the creek was surveyed on August 29. The segment runs from I-405 approximately 0.5 miles upstream (Figure 8). This segment of the creek appeared to be within a natural channel that flows through a section of mixed forest and several single family parcels that have mix of stream side vegetation such as lawn, trees and blackberries. The channel showed some signs of scouring and erosion along both banks, due to high flows. There is a small tributary and wetland system located approximately 50 feet upstream of 9<sup>th</sup> Avenue SE. The wetland is approximately 500 feet in length and flows into Crystal/Queensborough Creek from the south. This system consists mostly of a scrub shrub/forested wetland and a couple of constructed ponds. Although not verified, it is possible that waterfowl frequent these constructed ponds.

One point related to a 12" corrugated metal stormwater outlet from a detention pond was inspected (Figure 8). No visual or olfactory evidence was observed to suggest illicit discharges to the creek.

**Figure 8. CSS Segment Two**

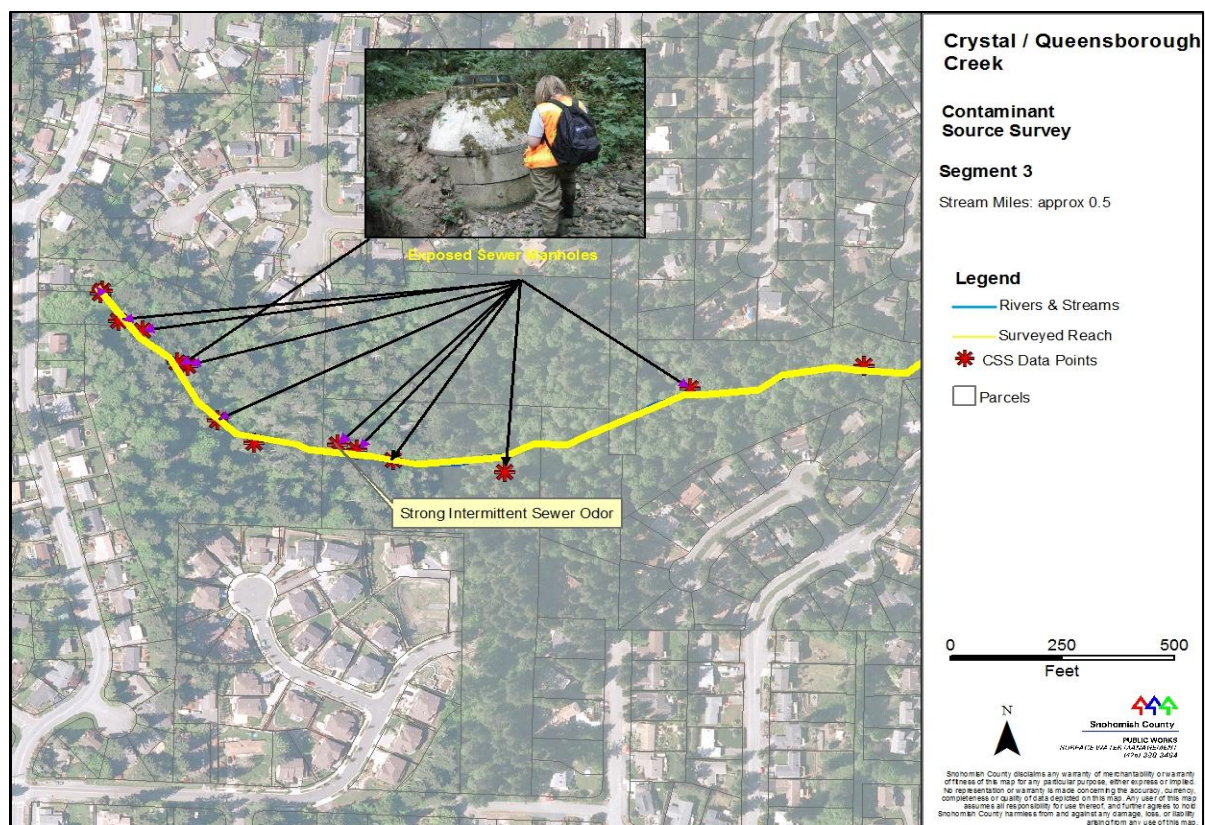


### Segment Three

Segment three was surveyed on August 30. The segment length is approximately 0.5 miles, ranging from 4<sup>th</sup> Ave SE to the headwaters at a stormwater outfall pipe at Meridian Avenue (Figure 9). The segment flows through a large mixed forested ravine, with heavy understory, bounded on both sides by older single family housing developments. Significant erosion occurs along both stream banks almost the entire length of the segment. Erosion is likely due to rain events, storm water discharge, streambed composition, and elevation drop.

Sewer pipe is buried alongside of or directly under much of the segments length. Scouring due to high flow is occurring around nine sewer standpipes and manhole access covers (Figures 9). Many of the exposed standpipes are within the channel wetted width and show signs of cracking and spalling. Although no standpipe was actively discharging sewage into the stream channel, the exposure is concern for potential ex-filtration, overflow and mixing with receiving waters during high flow events. In one location, a strong sewage odor was observed (Figure 9).

**Figure 9. CSS Segment three**



The upper reaches of segment three contained tarps, fire pits, chairs, bottles, toys and other garbage suggesting potential homeless encampments or temporary human use within the last year. Evidence of human encampment creates the potential for human feces to enter the creek.

## Recommendations

The Crystal/Queensborough Creek CSS did not identify active discharges to the creek. Potential discharges of human waste from spalling sewer standpipes and human use were observed. No evidence of domestic or wild animals was observed. Data review (2003-2007) found that standards are most frequently exceeded during the dry season. The City discontinued sampling the creek in 2007. As resources allow, the City should consider re-establishing a monthly sampling effort for fecal coliform bacteria over a minimum period of one water year at the historic location. This effort and volume of data would be sufficient for analysis in accordance with WAC 173-201A and the WQP.

Current conditions may suggest attainment of standards, corroborating the lack of observing any direct or ongoing discharges during the CSS. Newly acquired data which suggests attainment of standards could be submitted to Ecology during the freshwater call for data (mid-2016) to potentially change the listing category from 4a (impaired) to 1 (non-impaired). A non-impaired status would reduce the Cities programmatic obligations under future NPDES permits to reduce discharges of fecal coliform bacteria from the municipal stormwater system.

It is recommended the City coordinate with the local sewer district to determine risk of sewage ex-filtration, overflow or mixing with surface waters during high flow within segment three.

An effort to re-examine the upper reaches of segment three to confirm presence of human encampments and potential impacts would be beneficial. A stream clean up effort would help determine current or ongoing encampments or temporary use.

The City should consider focusing illicit discharge detection and elimination programs within the Crystal/Queensborough Creek sub-basin. Focused screening of the six known City outfalls, discharging to the creek, may trigger additional source tracking. Ongoing stormwater drainage system maintenance as required by the Cities Phase II NPDES permit may help reduce the discharge of pollutants from City drainage systems. Illicit discharge detection and elimination cross training of municipal staff responsible for maintenance would help identify potential discharges, and possibly improve efficiency.

## References

Britsch, Steve. 2009. Quality Assurance Project Plan for Snohomish River Tributaries, North and Swamp Creek. Fecal Coliform Bacteria Total Maximum Daily Load Monitoring. Snohomish County Public Works, Surface Water Management, Everett. WA.

[http://www.co.snohomish.wa.us/documents/Departments/Public Works/SWM/WQ-SnoCoQAPP-SnoRivTribStillyNoSwampLtBear-FecalTMDL.pdf](http://www.co.snohomish.wa.us/documents/Departments/Public%20Works/SWM/WQ-SnoCoQAPP-SnoRivTribStillyNoSwampLtBear-FecalTMDL.pdf)

Britsch, Steve. 2011 September. Little Bear Creek Dry Weather Data Summary Final. A Briefing for Project Partners and Stakeholders. *[Power Point Slides]*. Snohomish County Public Works, Surface Water Management, Everett. WA.

Britsch, S., Edwards, S., Oden, J., Purser., M. 2012 March. Snohomish County Microbial Water Quality Assessment. Fecal Coliform Bacteria. Contaminant Source Survey Methods. Snohomish County Public Works, Surface Water Management, Everett. WA.

Ecology. 2002. Overview of the Water Quality Assessment Process. Water Quality Policy 1-11 (revised September 2002). Additional clarifications of the binomial distribution method.

EPA. 2002. Guidance on Environmental Data Verification and Data Validation. Publication Number EPA QA/G-8.

Glenn, Norm. 2001. North Creek Watershed. Total Maximum Daily Load Evaluation for Fecal Coliform Bacteria. Washington State Department of Ecology, Bellevue, WA. Publication No 01-03-020. [www.ecy.wa.gov/biblio/0103020.html](http://www.ecy.wa.gov/biblio/0103020.html)

Jolley, L.W., W.R. English, and J.W. Pike. 2001. Should Sediment Reservoirs of Indicator Bacteria be Considered Nonpoint Sources. Department of Forestry and Natural Resources, Clemson University, Clemson, SC. Retrieved January 18, 2010, from <http://www.docstoc.com/docs/32096329/Should-bottom-sediments-be-considered-a-non-point>

Mathieu, Nuri. 2006. Replicate Precision for 12 TMDL Studies and Recommendation for Precision Measurement Quality Objectives for Water Quality Parameters. Washington State Department of Ecology, Bellevue, WA. Publication No 06-03-044. <https://fortress.wa.gov/ecy/publications/publications/0603044.pdf>

PBS&J. 2008. Fecal BMAP Implementation. Source Identification Hillsborough River Watershed. Final Summary Report. Prepared for Florida Department of Environmental Protection. Tallahassee, Florida.

Sargeant, Debby. 2000. Quality Assurance Project Plan for Dungeness River/Matriotti Creek Fecal Coliform Bacteria Total Maximum Daily Load Study. Washington State Department of Ecology, Bellevue, WA.

Thornburgh, K. 1996. The State of the Waters: Water Quality in Snohomish County's Rivers, Streams and Lakes, 1996 Assessment. Snohomish County Department of Public Works, Surface Water Management Division. Everett, Washington.

## **Appendix A**

### **NCLD - Fecal Coliform Bacteria Data Analysis over Last 30 Samples**

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| Site ID | Date       | Season | Fecal coliform bacteria (col/100ml) | Data Qualifier | Combined Season Geomean | Dry Season GeoMean | Wet Season Geomean | Geomean Standard | 10 % Not to Exceed Standard | Combined Season Count | Count Combined Season Samples >100 Colonies | Combined Season % Samples >100 Colonies | Count Dry Season Samples | Count Dry Season Samples >100 Colonies | % Dry Season Samples >100 Colonies | Count Wet Season Samples | Count Wet Season Samples >100 Colonies | % Wet Season Samples >100 Colonies | MWQA Ranking |
|---------|------------|--------|-------------------------------------|----------------|-------------------------|--------------------|--------------------|------------------|-----------------------------|-----------------------|---------------------------------------------|-----------------------------------------|--------------------------|----------------------------------------|------------------------------------|--------------------------|----------------------------------------|------------------------------------|--------------|
| NCLD    | 10/3/2012  | dry    | 66                                  | None           | 74                      | 116                | 47                 | 50               | 100                         | 30                    | 11                                          | 37                                      | 15                       | 7                                      | 47                                 | 15                       | 4                                      | 27                                 | C            |
| NCLD    | 9/5/2012   | dry    | 44                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 8/14/2012  | dry    | 54                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 7/11/2012  | dry    | 120                                 | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 6/1/2012   | dry    | 1800                                | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 10/12/2011 | dry    | 58                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 9/19/2011  | dry    | 150                                 | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 8/10/2011  | dry    | 340                                 | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 7/5/2011   | dry    | 76                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 6/1/2011   | dry    | 190                                 | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 10/4/2010  | dry    | 36                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 9/1/2010   | dry    | 900                                 | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 8/18/2010  | dry    | 60                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 7/12/2010  | dry    | 170                                 | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 6/1/2010   | dry    | 20                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 12/6/2012  | wet    | 140                                 | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 11/2/2012  | wet    | 200                                 | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 5/2/2012   | wet    | 96                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 4/2/2012   | wet    | 8                                   | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 3/6/2012   | wet    | 74                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 2/1/2012   | wet    | 380                                 | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 12/6/2011  | wet    | 28                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 11/2/2011  | wet    | 58                                  | J              |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 5/4/2011   | wet    | 58                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 4/4/2011   | wet    | 28                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 3/2/2011   | wet    | 12                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 2/1/2011   | wet    | 12                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 1/5/2011   | wet    | 34                                  | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 12/2/2010  | wet    | 2                                   | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |
| NCLD    | 11/1/2010  | wet    | 860                                 | None           |                         |                    |                    |                  |                             |                       |                                             |                                         |                          |                                        |                                    |                          |                                        |                                    |              |